

The Surfaces of Layered Transition Metal Oxides

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The strong mutual coupling between charge and spin of the electrons and the lattice degrees of freedom in transition-metal oxides (TMOs) results in effects such as charge-, orbital-, and spin-ordering; colossal magnetoresistance; and unconventional superconductivity. Conceptually, creating a surface is a controlled way to disturb the coupled system by breaking the symmetry. This unique environment could produce new phenomena, while providing a fresh approach to the study of the spin-charge-lattice coupling in these complex materials. This talk will focus on the geometric restructuring at the surface of several classes of TMOs and the resulting changes in the electronic and magnetic properties. The first class of TMOs to be discussed is the doped perovskites that exhibit CMR behavior. Thin films of $\text{La}_{0.65}\text{Sr}_{0.35}\text{MnO}_3$ prepared by RF sputtering in a 2:1 argon/oxygen atmosphere maintained at 20 mTorr exhibit copious segregation of Sr. The desire to segregate Sr is so great that the surface restructures into the non-perovskite Ruddlesden-Popper phase $(\text{La,Sr})_2\text{MnO}_4$ to accommodate a higher Sr concentration [1]. This 214 structured surface has an insulator-to-metal transition at 240 K compared to the bulk FM to PI transition at 370 K [2]. The second class of TMOs considered here is the undoped RP ($n=1$) Sr_2RuO_4 which can be easily cleaved in vacuum exposing large flat terraces of SrO termination. This surface reconstructs into a $(2 \times 2)R45^\circ$ configuration which experiment and theory show is a consequence of the compressive strain in the RuO_2 plane, resulting in a rotation of the octahedra [3]. The calculation of the surface structure for FM ordering in the surface illustrates what is so unique about these materials. The FM ordering stabilizes the distortion further and increases the rotation angle to 9° . Theoretically the ground state of the surface is FM. STM studies of the series $\text{Sr}_{2-2x}\text{Ca}_{2x}\text{RuO}_4$ ($0 < x < 1$) clearly reveals the effect of inhomogeneities in the doping concentration. The final example is a RP series ($n=1$) doped material, $\text{La}_{0.5}\text{Sr}_{1.5}\text{MnO}_4$. This material when cleaved also shows large flat terraces, but in contrast to Sr_2RuO_4 STM images reveal large spatial inhomogeneities in the band gap at the surface on the $\sim 10\text{nm}$ scale [4]. Evidence on a variety of doped TMOs indicates that these electronic inhomogeneities are intimately related to spatial inhomogeneous doping.

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2. A Surface Electronic Phase Transition in a CMR manganese Perovskite: $\text{La}_{0.65}\text{Sr}_{0.35}\text{MnO}_3$, H. Dulli, P. A. Dowben, J. Choi, Y. Feng, S.-H. Liou, and E. W. Plummer, *App. Phys. Lett.* **77**, ?? (2000).
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4. Surfaces: A playground for Physics with Broken Symmetry in Reduced Dimensionality, E. W. Plummer, R. Matzdorf, A. V. Melechko, J. Pierce and J. Zhang, *Surf. Science Vol. 500* (edited by C. B. Duke and E. W. Plummer)

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